Partial widths $a_0(980) \to \gamma\gamma$, $f_0(980) \to \gamma\gamma$ and $q\bar{q}$-classification of the lightest scalar mesons

A.V. Anisovich[(a)], V.V. Anisovich[(a)], D.V. Bugg[(b)], and V.A. Nikonov[(a)]

[(a)] St.Petersburg Nuclear Physics Institute, Gatchina, 188350 Russia,
[(b)] Queen Mary and Westfield College, Mile End Rd., London E1 4NS, UK

Abstract

We calculate partial widths for the decays $a_0(980) \to \gamma\gamma$ and $f_0(980) \to \gamma\gamma$ under the assumption that $a_0(980)$ and $f_0(980)$ are members of the basic $1^3P_0 q\bar{q}$ nonet. The results are in a reasonable agreement with data thus giving an argument for a $q\bar{q}$ origin of these mesons. We also calculate the $\gamma\gamma$ partial widths for the other scalar mesons, members of the $2^3P_0 q\bar{q}$ nonet.

1 Introduction

The determination of the lightest scalar $q\bar{q}$ nonet is a problem of principal importance both for quark systematics and the search for exotic states. The key query here is an understanding of the origin of $a_0(980)$ and $f_0(980)$ mesons: a study of decays $a_0(980) \to \gamma\gamma$ and $f_0(980) \to \gamma\gamma$ is an imperative step in the analysis of the structure of $a_0(980)$ and $f_0(980)$ (see, for example, [1] and references therein).

Here we perform the calculation of the scalar meson transition form factors $a_0(980) \to \gamma^*(q^2)\gamma$ and $f_0(980) \to \gamma^*(q^2)\gamma$ in the region of small q^2; these form factors, in the limit $q^2 \to 0$, determine the partial widths $a_0(980) \to \gamma\gamma$ and $f_0(980) \to \gamma\gamma$. Our calculation is based on the spectral representation technique developed in [2] for a study of the pseudoscalar meson transitions $\pi^0 \to \gamma^*(q^2)\gamma$, $\eta \to \gamma^*(q^2)\gamma$ and $\eta' \to \gamma^*(q^2)\gamma$.

In the region of moderately small q^2, where Strong-QCD works, the transition form factor $q\bar{q}$-meson $\to \gamma^*(q^2)\gamma$ is determined by the quark loop diagram of Fig. 1a which is a convolution of the $q\bar{q}$-meson and photon wave functions, $\Psi_{q\bar{q}} \otimes \Psi_\gamma$. The calculation of the process of Fig. 1a is performed in terms of the double spectral representation over $q\bar{q}$ invariant masses squared, $s = (m^2 + k_\perp^2)/(x(1-x))$ and $s' = (m^2 + k_\perp'^2)/(x(1-x))$ where $k_\perp^2$, $k_\perp'^2$ and x are the light-cone variables and m is the constituent quark mass. Following [2], we represent the photon wave function as a sum of two components which describe the prompt production of the $q\bar{q}$ pair at large s' (with a point-like vertex for the transition $\gamma \to q\bar{q}$, correspondingly) and the

production in the low-s' region where the vertex $\gamma \to q\bar{q}$ has a nontrivial structure due to soft $q\bar{q}$ interactions. The process of Fig. 1a at moderately small $|q^2|$ is mainly determined by the low-s' region, in other words by the soft component of the photon wave function.

The soft component of the photon wave function was restored in [2] on the basis of the experimental data for the transition $\pi^0 \to \gamma^*(q^2)\gamma$ at $|q^2| \le 1$ GeV^2. With the photon wave function found, the form factors $a_0 \to \gamma^*(q^2)\gamma$ and $f_0 \to \gamma^*(q^2)\gamma$ at $|q^2| \le 1$ GeV^2 provide the opportunity to investigate in detail the scalar meson wave functions. However, the current data do not allow to perform a full analysis, so we restrict ourselves by the consideration of a one-parameter representation of the wave function of scalar mesons, this parameter being the mean radius squared R^2.

Within the assumption about $q\bar{q}$ structure of the lightest scalar mesons, the flavour content of $a_0(980)$ is fixed, thus allowing unambiguous calculation of the transition form factor $a_0(980) \to \gamma\gamma$. We obtain reasonable agreement with data at $R^2_{a_0(980)} \sim (11-27)$ GeV^{-2} or, in terms of the pion radius squared, at $R^2_{a_0(980)}/R^2_\pi \sim 1.1 - 2.7$.

The partial width $\Gamma(f_0(980) \to \gamma\gamma)$ depends on the relative weight of the strange and non-strange components of the scalar/isoscalar meson, $s\bar{s}$ and $n\bar{n}$. For the region of not very large $R^2_{f_0(980)}$, $R^2_{f_0(980)}/R^2_\pi \sim 1.0 - 1.7$, the agreement with data is attained at relatively large $s\bar{s}$ component in $f_0(980)$, that is, of the order of $40 - 60\%$. It does not contradict the results of the analysis of two-meson spectra [3] according to which the lightest ($IJ^{PC} = 00^{++}$)-meson has a large $s\bar{s}$-component.

2 Decay amplitude and partial width

Below we present the formulae for the scalar/isoscalar meson decay $f_0 \to \gamma\gamma$. The formulae for $a_0 \to \gamma\gamma$ coincide in their principal points with those for $f_0 \to \gamma\gamma$.

The amplitude for the scalar meson two-photon decay has the following structure:

$$A_{\mu\nu} = e^2 g^{\perp\perp}_{\mu\nu}\, F_{f_0\gamma\gamma}(0,0)\,. \tag{1}$$

Here e is the electron charge ($e^2/4\pi = \alpha = 1/137$) and $F_{f_0\gamma\gamma}(0,0)$ is the form factor for the transition $f_0 \to \gamma(q^2)\gamma(q'^2)$ at $q^2 = 0$ and $q'^2 = 0$, namely, $F_{f_0\gamma\gamma}(0,0) = F_{f_0\gamma\gamma}(q^2 \to 0, q'^2 \to 0)$.

The metric tensor $g^{\perp\perp}_{\alpha\beta}$ determines the space perpendicular to q and q':

$$g^{\perp\perp}_{\alpha\beta} = g_{\alpha\beta} - q_\alpha q_\beta \frac{q'^2}{D} - q'_\alpha q'_\beta \frac{q^2}{D} + (q_\alpha q'_\beta + q'_\alpha q_\beta)\frac{(qq')}{D}\,, \tag{2}$$

where $D = q^2 q'^2 - (qq')^2$.

2.1 Partial width

The partial width, $\Gamma_{f_0\to\gamma\gamma}$, is determined as

$$m_{f_0}\Gamma_{f_0\to\gamma\gamma} = \frac{1}{2}\int d\Phi_2(p_{f_0}; q, q')\Sigma_{\mu\nu}|A_{\mu\nu}|^2 = \pi\alpha^2 |F_{f_0\gamma\gamma}(0,0)|^2\,. \tag{3}$$

Here m_{f_0} is the f_0-mass, the summation is carried over outgoing photon polarizations, the photon identity factor, $\frac{1}{2}$, is written explicitly, and the two-particle invariant phase space is equal to

$$d\Phi_2(p_{f_0};q,q') = \frac{1}{2}\,\frac{d^3q}{(2\pi)^3 2q_0}\,\frac{d^3q'}{(2\pi)^3 2q'_0}\,(2\pi)^4\delta^{(4)}\left(p_{f_0}-q-q'\right). \tag{4}$$

2.2 Form factor $F_{f_0\gamma\gamma}(q^2,q'^2)$

Following the prescription of Ref. [2], we present the amplitude of the process of Fig. 1a in terms of the spectral representation in the f_0 and $\gamma(q')$ channels. The double spectral representation reads

$$F_{f_0\gamma\gamma}(q^2,q'^2) = 2\int\limits_{4m^2}^{\infty}\frac{ds\,ds'}{\pi^2}\frac{G_{f_0}(s)}{s-m^2_{f_0}} \tag{5}$$

$$\times d\Phi_2(P;k_1,k_2)\;d\Phi_1(P\,';k'_1,k_2)\;Z_{f_0}T(P\,^2,P\,'^2,q^2)\sqrt{N_c}\,\frac{G_{\gamma\to q\bar q}(s')}{s'-q'^2}\,.$$

In the spectral integral (5), the momenta of the intermediate states differ from those of the initial/final states. The corresponding momenta for intermediate states are re-denoted as shown in Fig. 1b:

$$q\to P\;-P',\qquad q'\to P',\qquad p_{f_0}\to P\;, \tag{6}$$
$$P^2=s,\qquad P\,'^2=s',\qquad (P\,'-P)^2=q^2.$$

It should be stressed that $P\,'-P\neq q$. The two-particle phase space $d\Phi_2(P;k_1,k_2)$ is determined by Eq. (4), while the one-particle space factor is equal to

$$d\Phi_1(P\,';k'_1,k_2) = \frac{1}{2}\,\frac{d^3k'_1}{(2\pi)^3 2k'_{10}}(2\pi)^4\delta^{(4)}\left(P\,'-k'_1-k_2\right). \tag{7}$$

The factor Z_{f_0} is determined by the quark content of the f_0 meson: it is equal to $Z_{n\bar n} = (e_u^2+e_d^2)/\sqrt{2}$ for the $n\bar n$ component, and $Z_{s\bar s}=e_s^2$ for the $s\bar s$ component. The factor $\sqrt{N_c}$, where $N_c=3$ is the number of colours, is related to the normalization of the photon vertex made in Ref. [2]. We have two diagrams: with quark lines drawn clockwise and anticlockwise; the factor 2 in front of the right-hand side of Eq. (5) stands for this doubling. The vertices $G_{\gamma\to n\bar n}(s')$ and $G_{\gamma\to s\bar s}(s')$ were found in Ref. [2]; the wave function $G_{\gamma\to n\bar n}(s)/s$ is shown in Fig. 2.

We parametrize the f_0-meson wave function in the exponential form:

$$\Psi_{f_0}(s) = \frac{G_{f_0}(s)}{s-m^2_{f_0}} = Ce^{-bs}, \tag{8}$$

where C is normalization constant, and the parameter b can be related to the f_0-meson radius squared.

2.3 Spin structure factor $T(P^2, P'^2, q^2)$

For the amplitude of Fig. 1b with transverse polarized photons, the spin structure factor is fixed by the quark loop trace:

$$Tr[\gamma_\nu^{\perp\perp}(\hat{k}_1' + m)\gamma_\mu^{\perp\perp}(\hat{k}_1 + m)(\hat{k}_2 - m)] = T(P^2, P'^2, q^2)\; g_{\mu\nu}^{\perp\perp}\,. \tag{9}$$

Here $\gamma_\nu^{\perp\perp}$ and $\gamma_\mu^{\perp\perp}$ stand for photon vertices, $\gamma_\mu^{\perp\perp} = g_{\mu\beta}^{\perp\perp}\gamma_\beta$, while $g_{\mu\beta}^{\perp\perp}$ is determined by Eq. (2) with the following substitution $q \to P - P'$ and $q' \to P'$. Recall that the momenta k_1', k_1 and k_2 in (9) are mass-on-shell.

One has

$$T(s, s', q^2) = -2m\left[4m^2 - s + s' + q^2 - \frac{4ss'q^2}{2(s+s')q^2 - (s-s')^2 - q^4}\right]. \tag{10}$$

2.4 Light cone variables

The formula (5) allows one to make easily the transformation to the light cone variables using the boost along the z-axis. Let us use the frame in which the initial f_0-meson is moving along the z-axis with the momentum $p \to \infty$:

$$P = (p + \frac{s}{2p}, 0, p), \qquad P\,' = (p + \frac{s' + q_\perp^2}{2p}, \vec{q}_\perp, p). \tag{11}$$

Then the transition form factor $f_0 \to \gamma(q^2)\gamma$ reads:

$$F_{f_0\gamma\gamma}(q^2, 0) = \frac{2Z_{f_0}\sqrt{N_c}}{16\pi^3}\int\limits_0^1 \frac{dx}{x(1-x)^2}\int d^2k_\perp \Psi_{f_0}(s)\Psi_\gamma(s')T(s, s', q^2), \tag{12}$$

where $x = k_{2z}/p$, $\vec{k}_\perp = \vec{k}_{2\perp}$, and the $q\bar{q}$ invariant masses squared are

$$s = \frac{m^2 + k_\perp^2}{x(1-x)}, \qquad s' = \frac{m^2 + (\vec{k}_\perp - x\vec{q}_\perp)^2}{x(1-x)}. \tag{13}$$

2.5 Meson charge form factor

In order to relate the wave function parameters C and b of Eq.(8) to the f_0-meson radius squared, we calculate the meson charge form factor shown diagrammatically in Fig. 1c. The amplitude has the following structure

$$A_\mu = (p_{f_0\mu} + p'_{f_0\mu})F_{f_0}(q^2),$$

where the meson charge form factor $F_{f_0}(q^2)$ is a convolution of the f_0-meson wave functions $\Psi_{f_0} \otimes \Psi_{f_0}$:

$$F_{f_0}(q^2) = \frac{1}{16\pi^3}\int\limits_0^1 \frac{dx}{x(1-x)^2}\int d^2k_\perp \Psi_{f_0}(s)\Psi_{f_0}(s')S(s,s',q^2). \qquad (14)$$

$S(s,s',q^2)$ is determined by the quark loop trace in the intermediate state:

$$Tr[(\hat{k}_1+m)\gamma_\mu^\perp(\hat{k}'_1+m)(\hat{k}_2-m)] = [P'_\mu + P_\mu - \frac{s'-s}{q^2}(P'_\mu - P_\mu)]\ S(s,s',q^2), \qquad (15)$$

where

$$\gamma_\mu^\perp = g_{\mu\nu}^\perp\ \gamma_\nu\ , \qquad g_{\mu\nu}^\perp = g_{\mu\nu} - (P'_\mu - P_\mu)(P'_\nu - P_\nu)/q^2\ . \qquad (16)$$

One has

$$S(s,s',q^2) = \frac{q^2(s'+s-q^2)(s'+s-q^2-8m^2)}{2(s+s')q^2-(s'-s)^2-q^4} + q^2. \qquad (17)$$

The low-$q_\perp^2$ charge form factor,

$$F_{f_0}(q^2) \simeq 1 - \frac{1}{6}R^2 q_\perp^2, \qquad (18)$$

determines the f_0-meson wave function parameters, C and b.

2.6 First radial excitation states, $2^3P_0 q\bar{q}$

Equation (8) stands for the wave function of the basic state; the wave function of the first radial excitation can be written within an exponential approximation as

$$\Psi^{(1)}_{f_0}(s) = C_1(D_1 s - 1)e^{-b_1 s}\,. \qquad (19)$$

The parameter b_1 can be related to the radius of the radial excitation state, then the values C_1 and D_1 are fixed by the normalization and orthogonality requirements, $\left[\Psi^{(1)}_{f_0}\otimes\Psi^{(1)}_{f_0}\right]_{q^2=0} = 1$ and $\left[\Psi_{f_0}\otimes\Psi^{(1)}_{f_0}\right]_{q^2=0} = 0$.

3 Results

Using Eqs. (8), (12) and (19), we calculate $\gamma\gamma$ partial widths of the $1^3P_0 q\bar{q}$ and $2^3P_0 q\bar{q}$ mesons.

3.1 Partial widths $a_0(980)\to\gamma\gamma$ and $a_0(1450^{+90}_{-20})\to\gamma\gamma$

The partial width $\Gamma(a_0(980)\to\gamma\gamma)$ is determined by the same equation as for $f_0(980)$-decay, Eq. (12), with the only substitution $Z_{f_0}\to Z_{a_0} = (e_u^2 - e_d^2)/\sqrt{2} = 1/(3\sqrt{2})$. The value $\Gamma(a_0(980)\to\gamma\gamma)$ is shown in Fig. 3 as a function of $R^2_{a_0(980)}$. Experimental study of $\Gamma(a_0(980)\to\gamma\gamma)$ was carried out in Refs. [5, 6], the averaged value is: $\Gamma(\eta\pi)\cdot\Gamma(\gamma\gamma)/\Gamma_{total} = 0.24^{+0.08}_{-0.07}$ keV [4]. Using $\Gamma_{total}\simeq\Gamma(\eta\pi)+\Gamma(K\bar{K})$, we have $\Gamma(a_0(980)\to\gamma\gamma) = 0.30^{+0.11}_{-0.10}$ keV. The calculated value of

$\Gamma(a_0(980) \to \gamma\gamma)$ agrees with data at $R^2_{a_0(980)} = 19 \pm 8$ GeV^{-2}: this value looks quite reasonable for a meson of the $1^3P_0q\bar{q}$ multiplet.

If $a_0(980)$ is a member of the basic $1^3P_0q\bar{q}$ multiplet, the scalar/isoscalar meson $a_0(1450^{+90}_{-20})$ is the first radial excitation meson, a member of the $2^3P_0q\bar{q}$ multiplet. Figure 3b demonstrates the values of partial widths $\Gamma(a_0(1450^{+90}_{-20}) \to \gamma\gamma)$: in the calculation, we use $m_{a0(1450^{+90}_{-20})} = 1535$ MeV following the results of the analysis [7] and put $R_{a_0(1450)}/R_{a_0(980)} \simeq 1.22$ assumimg that radii of the mesons of the $2^3P_0q\bar{q}$ multiplet are larger than those for $1^3P_0q\bar{q}$.

The transition form factor $F_{a_0(1450)\gamma\gamma}$ is a convolution of two wave functions, $\Psi_{a_0(1450)} \otimes \Psi_\gamma$, one of them being the wave function of the first radial excitation changes the sign, see Eq. (19). This fact results in a relative suppression of the decay $a_0(1450^{+90}_{-20}) \to \gamma\gamma$: $\Gamma(a_0(1450^{+90}_{-20}) \to \gamma\gamma)/\Gamma(a_0(980) \to \gamma\gamma) \sim 1/10$.

3.2 Partial $\gamma\gamma$-widths for scalar/isoscalar mesons of $1^3P_0q\bar{q}$ and $2^3P_0q\bar{q}$ multiplets

In the analysis of $f_0 \to \gamma\gamma$ decays, one should take into account that the scalar/isoscalar mesons in the mass range $1-2$ GeV are mixtures of not only $n\bar{n}$ and $s\bar{s}$ components but the gluonium state as well. Therefore, the transition form factor of the f_0-meson reads:

$$F_{f_0\gamma\gamma} = \cos\alpha\,(\cos\phi\, F_{f_0(n\bar{n})\gamma\gamma} + \sin\phi\, F_{f_0(s\bar{s})\gamma\gamma}) \quad (20)$$

where $\sin^2\alpha$ is the probability of the gluonium component in f_0-meson, and ϕ is mixing angle for $n\bar{n}$ and $s\bar{s}$ components: $\psi^{flavour}_{f_0} = \cos\phi\, n\bar{n} + \sin\phi\, s\bar{s}$. According to the estimations of Ref. [8], $\cos^2\alpha \sim 0.7-0.9$ for the f_0-mesons of $1^3P_0q\bar{q}$ and $2^3P_0q\bar{q}$ multiplets.

Figure 3c demonstrates the partial $\gamma\gamma$-widths for $f_0(980)$ calculated under assumptions that $f_0(980)$ is either a pure $n\bar{n}$ state (solid curve) or pure $s\bar{s}$ (dashed curve). Experimental analyses give $\Gamma(f_0(980) \to \gamma\gamma) = 0.42 \pm 0.06 \pm 0.18$ keV [5] and $\Gamma(f_0(980) \to \gamma\gamma) = 0.63 \pm 0.14$ keV [9]; the averaged value reads: $\Gamma(f_0(980) \to \gamma\gamma) = 0.56 \pm 0.11$ keV [4]. Our calculation shows that this value can be easily understood if $f_0(980)$ has a significant $s\bar{s}$ component. For example, for $R^2_{f_0(980)} = 11$ GeV^{-2} and $\alpha = 0$, the data can be described either with $\phi \simeq -35^o$ or $\phi \simeq 63^o$. The existence of a significant $s\bar{s}$-component in $f_0(980)$ agrees with the results of analysis [3] for the two-meson spectra.

Figure 3d shows the $f_0(1500) \to \gamma\gamma$ partial widths calculated for pure $n\bar{n}$ and $s\bar{s}$ components within the assumption that these $q\bar{q}$ components belong to 2^3P_0 multiplet. One can see a strong suppression of the $\gamma\gamma$ decay mode for both components, $n\bar{n}$ and $s\bar{s}$. The origin of this suppression is the same as for the decay $a_0(1450^{+90}_{-20}) \to \gamma\gamma$: this is an approximate orthogonality of the photon and $(2^3P_0q\bar{q})$-meson wave functions in the coordinate/momentum space.

4 Conclusion

Here we continue the investigation of the meson two-photon decays started in Ref. [2], where the partial widths $\pi \to \gamma\gamma$, $\eta \to \gamma\gamma$ and $\eta' \to \gamma\gamma$ were calculated. In the present paper, we

have calculated partial widths $a_0(980) \to \gamma\gamma$ and $f_0(980) \to \gamma\gamma$ assuming that the mesons $a_0(980)$ and $f_0(980)$ are members of the basic $1^3P_0 q\bar{q}$ multiplet: the results are in a reasonable agreement with the data. This supports the idea of $q\bar{q}$ origin of the scalar mesons $a_0(980)$ and $f_0(980)$ and gives the argument that the lightest scalar nonet is located near 1000 MeV (see discussion in Refs. [10, 11] and in references therein).

A successful description of the data is due to two principal points taken into account in the calculation: (i) the spin structure and relativistic corrections are included into consideration in the framework of the relativistic light-cone technique, (ii) the subprocess $q\bar{q} \to \gamma\gamma$, which was found previously in [2], is used in the numerical analysis.

We are graceful to L.G. Dakhno, D.I. Melikhov and A.V. Sarantsev for useful discussions. The paper is suppored by grants RFFI 96-02-17934 and INTAS-RFBR 95-0267.

References

[1] T. Barnes, *Theoretical Aspects of Light Meson Spectroscopy*, in: Hadron Spectroscopy and the Confinement Problem, Edited by D.V. Bugg, Plenum Press, New York (1996);
E. Klempt, *Hadron '97 Summary*, in: Hadron Spectroscopy, AIP Coference Proceedings 432, Editors S.-U. Chung and H.J. Willutzki, Woodbury, New York (1998).

[2] V.V. Anisovich, D.I. Melikhov, V.A. Nikonov, Phys. Rev. **D55** (1997) 2918 ; Phys. Rev. **D52** (1995) 5295;
V.V. Anisovich, D.V. Bugg, D.I. Melikhov, V.A. Nikonov, Phys. Lett. **B404** (1997) 166.

[3] V.V. Anisovich, Yu.D. Prokoshkin, A.V. Sarantsev, Phys. Lett. **B389** (1996) 388.

[4] C. Caso et al. (PD Group), Eur. Phys. J. **C3**, (1998) 1.

[5] T. Oest et al. (JADE Coll.) Z. Phys. **C47** 343 (1990).

[6] D. Antreasyan et al. (Crystal Ball Coll.) Phys. Rev. **D33** (1986) 1847.

[7] V.V. Anisovich, A.A. Kondashov, Yu.D. Prokoshkin et al. *Two-pion spectra for the reaction* $\pi^- p \to \pi^0\pi^0 n$ *at 38 GeV/c pion momentum and combined analysis of the GAMS, Crystal Barrel and BNL data*, hep-ph/9711319, unpublished.

[8] A.V. Anisovich, V.V. Anisovich, A.V. Sarantsev, Z. Phys. **A359** (1997) 173; Phys. Lett. **B395** (1997) 123.

[9] D. Morgan, M. Pennington, Z. Phys. **C48** (1990) 623.

[10] A.V. Anisovich, A.V. Sarantsev, Phys. Lett. **B413** (1997) 137.

[11] V.V. Anisovich *The lightest scalar glueball: retrospective view and the current state of the problem*, in: Hadron Spectroscopy, AIP Coference Proceedings 432, Editors S.-U. Chung and H.J. Willutzki, Woodbury, New York (1998).

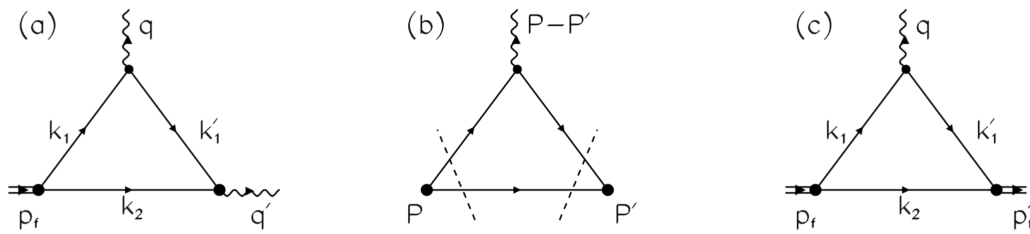

Figure 1: a) Triangle diagram for the transition form factor $f_0 \to \gamma(q^2)\gamma(q'^2)$. b) Diagram for the double spectral representation over $P^2 = s$ and $P'^2 = s'$, Eq. (5); the intermediate state particles are mass-on-shell, the cuttings of the diagram are shown by dashed lines. c) Triangle diagram for the meson charge form factor.

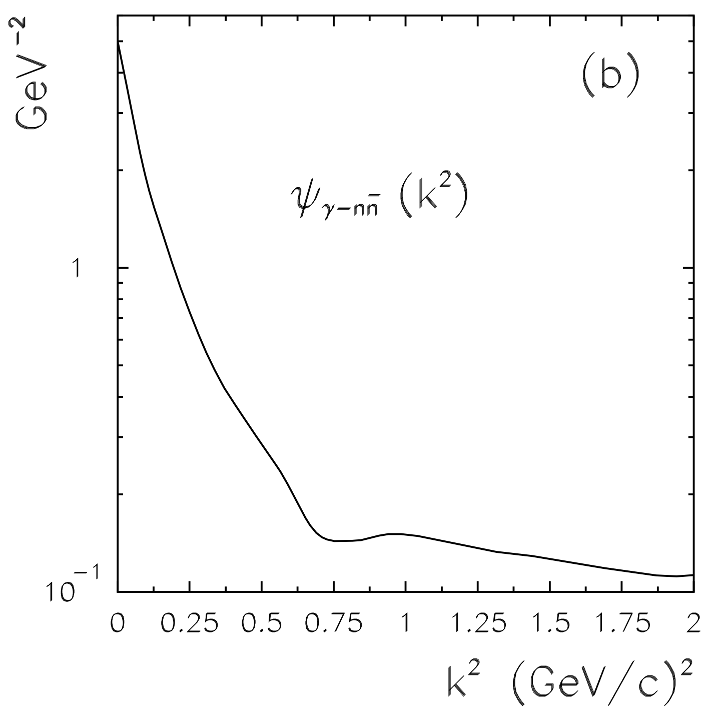

Figure 2: Photon wave function for non-strange quarks, $\psi_{\gamma\to n\bar{n}}(k^2) = g_\gamma(k^2)/(k^2 + m^2)$, where $k^2 = s/4 - m^2$; the wave function for the $s\bar{s}$ component is equal to $\psi_{\gamma\to s\bar{s}}(k^2) = g_\gamma(k^2)/(k^2 + m_s^2)$ where m_s is the constituent s-quark mass.

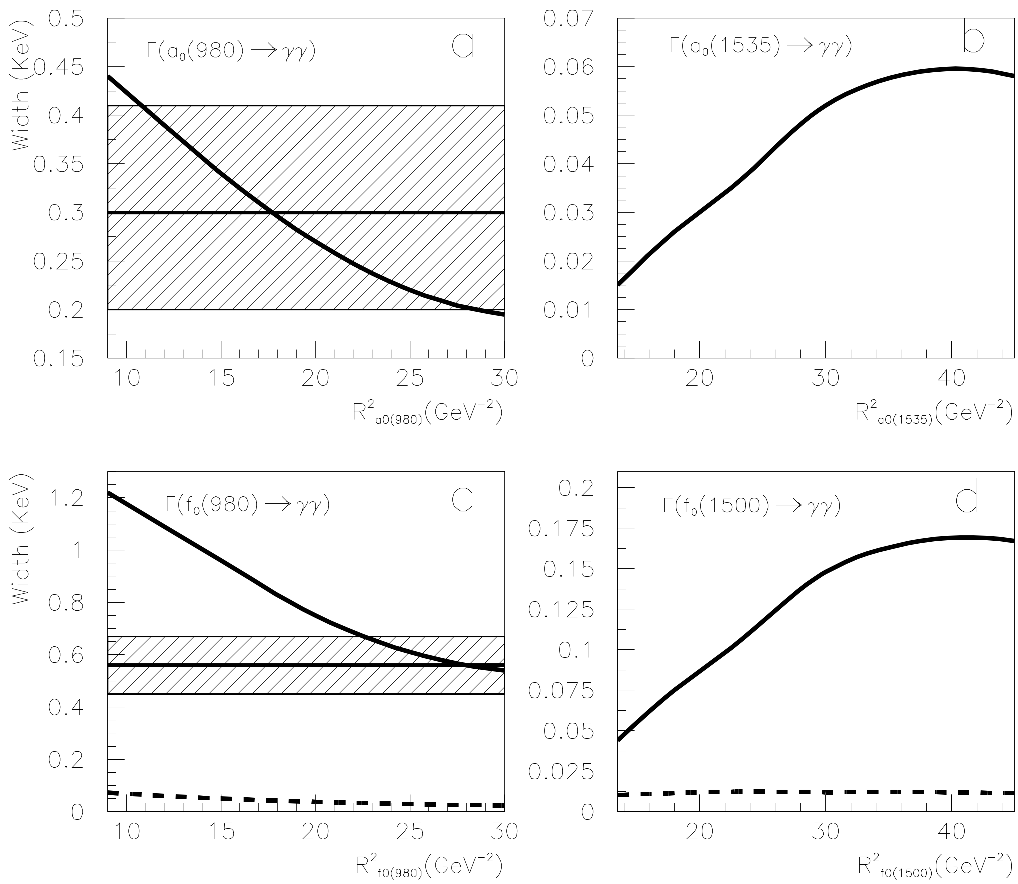

Figure 3: The calculated partial widths (solid and dashed curves) versus meson radius squared and the experimental data (scratched areas). For the scalar/isoscalar mesons, $f_0(980)$ and $f_0(1500)$, the dashed curves stand for the pure $s\bar{s}$ content and the solid ones for the pure $n\bar{n}$.